Circadian Lighting And Wellness

LHRC – Better Light, Better Sleep

A. LHRC laboratory and field studies have shown that exposure to a CS of 0.3 or greater for at least two hours per day, especially in the morning, is effective for improving sleep quality, mood, and alertness and reducing stress in office workers, as well as for reducing depression in people with Alzheimer's disease and related dementias living in long-term care facilities.

B. Recommends limiting evening light exposures to CS ≤ .1 at the eye

C. Luminance of <8500cd/m^2

Minimum of 40 fc at the eye during the day

Maximum of 5 fc at the eye during the evening

Off at Night time.

TIME OF DAY	CS
Early morning (8–11 am)	≥ 0.3
Late morning through early afternoon (11 am to 3 pm)	0.2
Late afternoon through evening (after 3 pm)	≤ 0.1

- Determine the spectrum and light level. Increasing the horizontal light level to 500 lx will increase the likelihood of reaching a CS of 0.3, regardless of spectrum if only white light sources are being used in the space. While more products are becoming available that tout special "optimized" polychromatic spectra for circadian stimulation, this strategy may come at a steep energy cost, as shown in Figure 3. The "spectrally optimized" source provided slightly higher CS than the standard 3500K recessed linear luminaire but required 70% more energy to achieve a CS of 0.3. The luminous efficacy of such sources is likely to improve over time, but care should be taken when considering them for your design. Because the circadian system is so sensitive to short-wavelength light (peak close to 460 nm), supplemental narrowband blue distributions, or direct/indirect pendants with a "batwing" indirect component. light can be particularly useful when strict energy efficiency requirements, horizontal illuminance, CCT and or aesthetic constraints make CS delivery difficult from traditional overhead luminaires alone. To achieve a CS of 0.3, 8 lx of blue light at the eye (in addition to the 2-ft by 2-ft troffer delivering 300 lx horizontal at 3000K) was needed from the supplemental layer, for an additional 0.09 watts per sq ft. For a CS of 0.4, 16 lx of blue light was needed for an additional 0.17 watts per sq ft. Using supplemental blue light was the most effective means of providing a CS of 0.3 for as little energy as possible without exceeding a CCT of 5000K.

- If using blue light is not an option, design the overhead lighting to provide adequate CS and maximize CS:LPD. Light must reach the retina to affect the circadian system. Therefore, sources with relatively wider intensity distributions that deliver more light in the vertical plane will provide more circadian-effective light per watt compared to narrow beam sources. It is important to evaluate the intensity distribution of the luminaire you are considering. Look for those with a vertical-to horizontal illuminance ratio of at least 0.6:1, such as troffers with wide, diffuse

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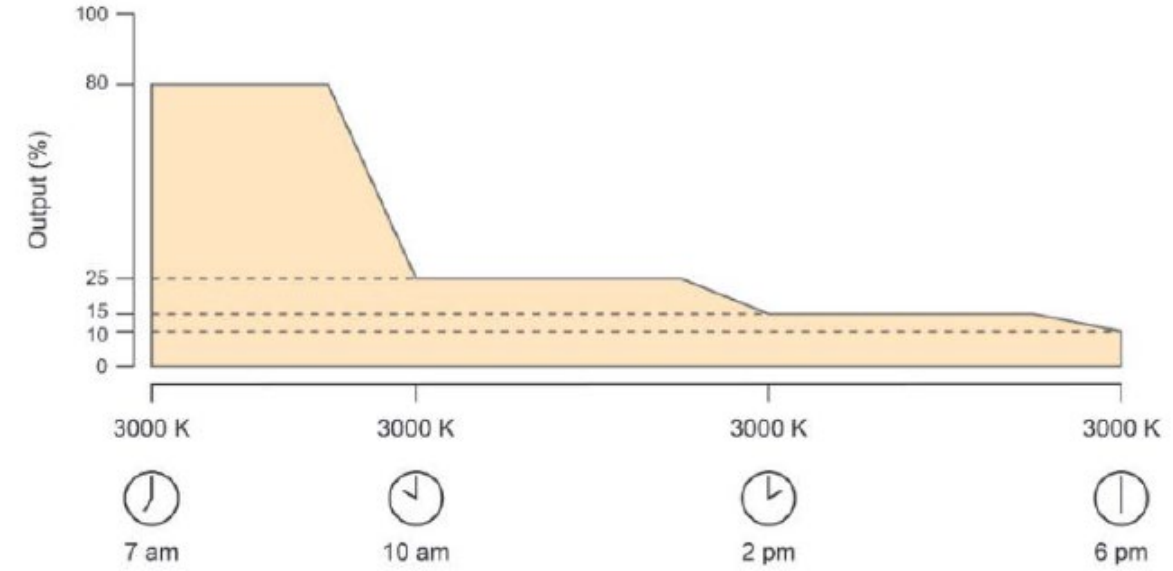
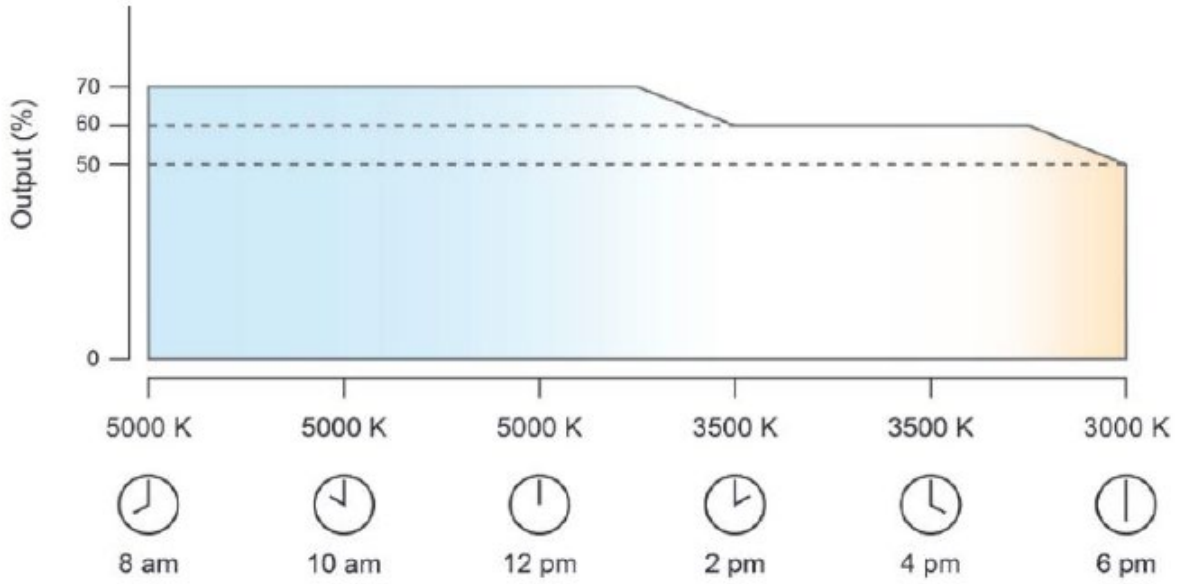
- Both static white and color tuning are fine if both day and evening outputs can be achieved
- Low color temperature (< 3000 K) will require higher illuminance (and wattage) at the eye compared to high color temperature (> 4500 K)
- Color Rendering: ≥ 80 CRI



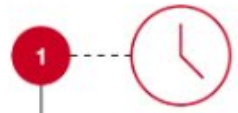


UL24480 Design Guideline:

Promoting Circadian Entrainment with Light for Day-Active People

How to achieve indoor circadian entrainment utilizing the CS method.

0.3 Circadian Stimulis (CS) Method
There are many ways to achieve circadian-effective lighting. This six-step workflow is based on the CS method, and is designed to deliver the required photopic luminance at the eye.



Establish a lighting design criteria
UL DG 24880: For two hours during the day, provide light at the eye equivalent to that which would suppress the hormone melatonin at night.

Select your luminaire types
From the photometric distribution, know the amount of light entering the observer's eyes, characterized by the vertical-to-horizontal illuminance ratio (E_v/E_h).

Select your luminaire's SPD
Based on your budget, select a fixed CCT or a color-tunable CCT (not all CCTs are the same). Color tunable can be more energy efficient.

Perform CAD calculations
Use your lighting CAD program to determine the E_v contributions at the observer's eyes. Capture at least ten representative sample locations.

Calculate the Circadian Stimulus
Determine the CS number achieved using the free online Circadian Design Calculator by entering the SPD (step 3) and E_v (step 4).

Does your design reach a CS of 0.3?
If the desired goal was not met, alter the lighting design and repeat the previous steps. Consider adding layers of light not in the ceiling plane, or improving reflectances of surfaces.

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WELL Building Standard

Feature 54 Circadian Lighting Design

Light is one of the main drivers of the circadian system, which starts in the brain and regulates physiological rhythms throughout the body's tissues and organs, affecting hormone levels and the sleep-wake cycle. Circadian rhythms are kept in sync by various cues, including light which the body responds to in a way facilitated by intrinsically photosensitive retinal ganglion cells (ipRGCs): the eyes' non-image forming photoreceptors. Through ipRGCs, lights of high frequency and intensity promote alertness, while the lack of this stimulus signals the body to reduce energy expenditure and prepare for rest. This feature promotes lighting environments for circadian health. The biological effects of light on humans can be measured in Equivalent Melanopic Lux (EML), a proposed alternate metric that is weighted to the ipRGCs instead of to the cones, which is the case with traditional lux. Tables L1 and L2 in Appendix C show how to calculate the EML of individual lamps and larger spaces.

Work areas

Daytime - Greater than or equal to 200 EML at 75% or more of the workspaces OR 150 EML at 100% of the workspaces

Living Environments

Daytime: Greater than or equal to 200 EML

Nightime: Less than or equal to 50 EML

Breakrooms

Greater than or equal to 250 EML

Learning

125 EML for 4 hours a day

Well Building Standard

Feature 55 Glare Control

Non-diffuse, bright indoor lights create uneven levels of brightness in the visual field. The resulting glare, defined as “excessive brightness of the light-source, excessive brightness-contrasts and excessive quantity of light”, can cause visual discomfort (discomfort glare), fatigue, visual impairment and even injury (disability glare), and can be attributed to either direct or reflected glare. In the case of glare caused by electric light sources, lamps should be shielded based on their luminance.

This feature sets limits on glare based on measures of luminous intensity or luminance per area of the light source. This quantity, often given in cd/m², can be measured directly or calculated from lighting specification sheets with sufficient detail. Light fixtures of greater luminous intensity require a greater shielding angle to reduce the likelihood of creating direct glare for occupants

Part 1: Lamp Shielding

Lamps with the following luminance in regularly occupied spaces are shielded by the angles listed below or greater:

A. Less than 20,000 cd/m², including reflected sources: no shielding required.
B. 20,000 to 50,000 cd/m²: 15°.
C. 50,000 to 500,000 cd/m² : 20°.
D. 500,000 cd/m² and above: 30°.

Part 2: Glare Minimization

At workstations and desks, the following requirement is met:

A. Bare lamps and luminaire surfaces more than 53° above the center of view (degrees above horizontal) have luminances less than 8,000 cd/m².

WELL Building Standard

Feature 58 Color Quality

Color quality is a function of the spectral output of a light source, the spectral absorbance/reflectance of an object, and the sensitivity of the eye's cone photoreceptors to different wavelengths of light, which we perceive as color. Color quality impacts visual appeal and can either contribute to or detract from occupant comfort. Poor color quality can reduce visual acuity and the accurate rendering of illuminated objects. For instance, foods, human skin tones and plants may appear dull or unsaturated under lights that have low color quality metrics.

This feature relies on the use of the color rendering index (CRI): a common way to measure color quality, capturing R1-R8 metrics. R9, while not always reported, is also included as part of this feature, as R9 values further take into consideration how we perceive the saturation of warmer hues.

Part 1: Color Rendering Index

To accurately portray colors in the space and enhance occupant comfort, all electric lights (except decorative fixtures, emergency lights and other special-purpose lighting) meet the following conditions:

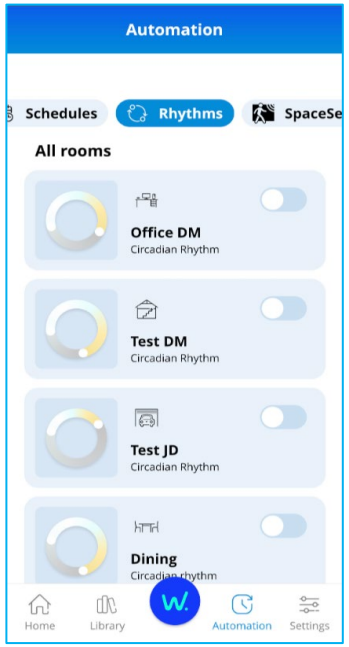
A. Color Rendering Index Ra (CRI, average of R1 through R8) of 80 or higher.

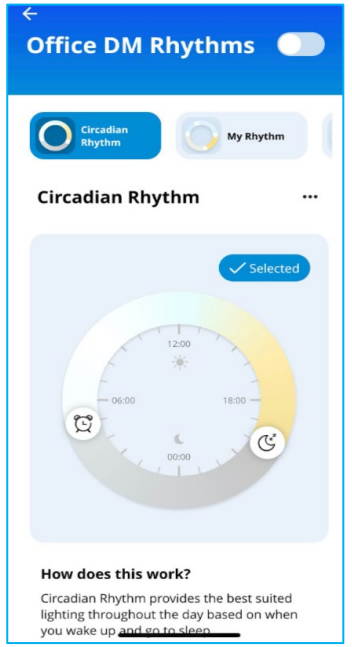
B. Color Rendering Index R9 of 50 or higher.

Optimizing your Circadian Rhythm with the WiZ App

Circadian Rhythm Feature:

1. Lights using the Circadian rhythm will gradually brighten in the morning, using cool white.
2. The white will then become more neutral and even brighter during the day.
3. When evening gets closer, the lights will start to dim and get warmer, until they eventually turn into night light mode for bedtime.
4. You can adjust the time for wake-up and bedtime, and the rhythm will adapt automatically. To do so, tap on "Edit" at the bottom of the Circadian rhythm card.

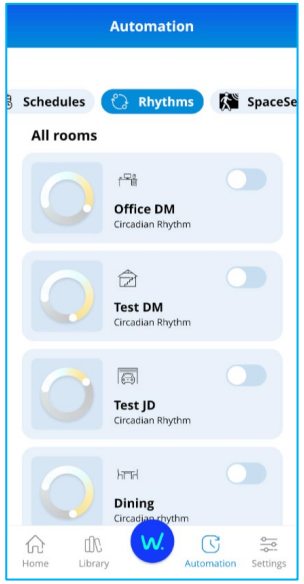


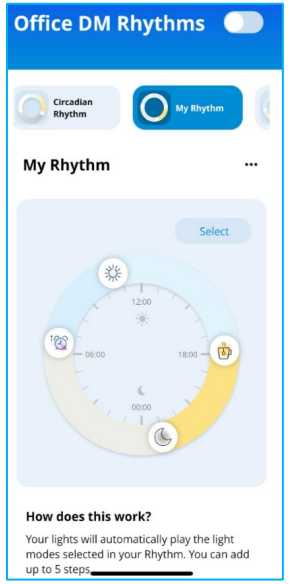


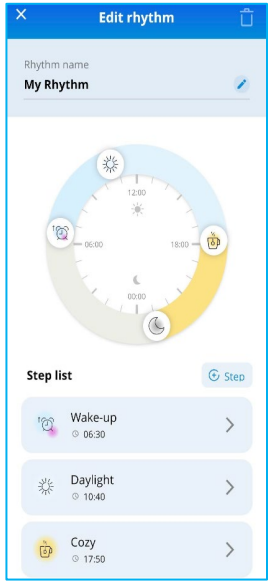
Optimizing your Circadian Rhythm with the WiZ App

Custom Rhythm Feature:

1. The Custom Rhythm feature allows for a higher level of customization to the automation. If you'd like to put the tools learned in this module to good use, you can prescribe your own automation to tune your lights to the preferred color temperatures and brightness levels that you find appealing and comfortable but that also check the boxes with regard to circadian-effective lighting.
2. You can set up to 5 different light points allowing you to custom-tailor how your lighting shifts as the day progresses. For each light point/time you'll select the the light mode that you'd like to be triggered and the duration for it to be in effect. With custom rhythms you have control over the cycle that your lighting will go through but can still achieve the necessary CCT and brightness levels that you're bodies natural clock is kept in line with nature.

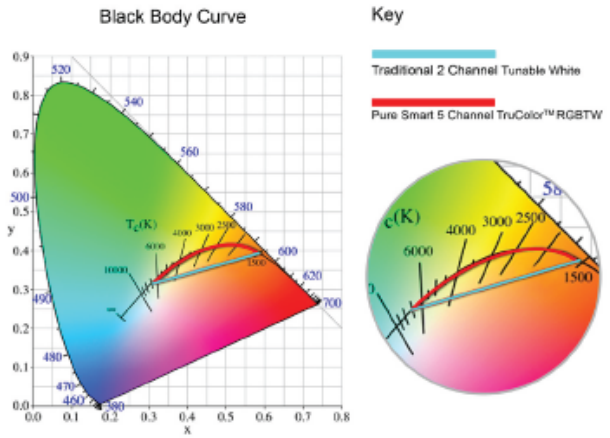






What is TruColor?

Pure Smart™ TruColor™ technology uses five-channels of tunable LEDs, composed of RGBTW (Red, Blue, Green, Warm White, and Cool White). With our proprietary color mixing we produce one of the widest, most accurate spectrums available from 1500K-6500K, giving our customers access to the warm glow of the sunset (1500K-2400K golden hour) to the white light of the mid-day sun (5700K) and beyond. TruColor LED's achieve an average CRI-Colo Rendering Index of 94 and a Duv of +-.0032 in relation to the blackbody curve at any point on the spectrum of tunable white CCT.



TruColor™ offers tunable white with all the vibrancy in colors from sunrise to sunset

SUNRISE	MORNING	NOON	AFTERNOON	SUNSET
<2000K	3500-4500K	5500-6500K	3500-4500K	<2000K

Tunable White

Enjoy easy set up and endless control with PureSmart™ Lighting